# Reform of Aircraft Maintenance Regulations
# Regulation Impact Statement

## Parts 42, 66, 145 and 147 of the
## Civil Aviation Safety Regulations

**SUMMARY**

Australia's current aircraft maintenance regulations have not fully responded to the advancement in aircraft technology or fully incorporated the findings of aviation safety research, which can compromise both aviation safety and efficiency. For example:

- with the increasing use of electronics to control mechanical parts, the current regulations require up to three categories of licensed engineer to service an electronic fuel control, whereas in other countries this task could be performed by one suitably qualified engineer
- safety analysis has revealed that a number of accidents and safety incidents are caused by the failure of organisations to adopt a safety management system to identify and respond to safety risks

CASA is proposing changes that will involve:

- businesses operating regular pubic transport aircraft preparing an exposition of how they will ensure the continuing airworthiness of their aircraft, which will include a periodic aircraft inspection and review
- aircraft maintenance businesses developing an exposition and implementing a safety management system and training their staff in human factors, if they are to hold an approval to service regular public transport aircraft
- new aircraft maintenance engineers being required to complete competency based training such as a diploma or equivalent. The existing licence categories for engineers that determine who is required to certify the release of aircraft after maintenance work, will be aligned with the maintenance requirements of modern aircraft

The proposed changes are expected to provide a safety benefit by improving the systems that aircraft operators use to ensure the safety of their aircraft and reducing the number of errors committed by businesses maintaining aircraft. The improvement of safety systems and the reduction of maintenance errors will also improve the efficiency of aviation operations, such as reducing the number of flight delays and cancellations. A major benefit of the changes will be derived from improving the efficiency of the certification of maintenance work by engineers. Over a 15 year period the benefits are estimated to be $308m.

Maintenance businesses will incur a cost to prepare an exposition and implement a safety management system. Aircraft operators will be required to prepare an airworthiness exposition and undertake periodic aircraft inspections. The costs over 15 years are estimated to be $153m.

Overall the proposed changes are estimated to provide a small net benefit to the aviation industry and the community overall, estimated at $155m over the next 15 years. The benefit and cost estimates are subject to uncertainty and a sensitivity analysis was undertaken to reflect that uncertainty. Under the worst case scenario the estimated net benefit is $56m.

CASA consulted extensively with affected stakeholders, including the publication of a Notice of Proposed Rule Making. The changes were generally supported by the major aircraft operators and large maintenance organisations, however, the union representing licensed engineers expressed concern about changes to the training and licensing system.

## Problem

The current regulations of aircraft maintenance aim to reduce the risk of aircraft maintenance errors leading to an aviation accident. Under current regulations, aircraft operators are required to engage a CASA approved maintenance organisation to maintain the airworthiness of their aircraft. Ongoing airworthiness requires a business to either:

> follow the aircraft manufacturers' schedule of maintenance, which outlines what maintenance tasks need to be performed at specified intervals and how they will be undertaken; or
>
> follow an alternative maintenance schedule that has been approved by CASA

Maintenance organisations are required to employ licensed engineers to certify maintenance work and the airworthiness of aircraft.

*Safety Risk*

The current regulations, whilst reducing the risk of a maintenance error leading to an aviation accident, do not completely eliminate this safety risk. Analysing Australia's aircraft maintenance sector the Australian Transport Safety Bureau (ATSB) concluded that:

> Improper maintenance contributes to a significant proportion of aviation accidents and incidents. This is because a small percentage of maintenance tasks are performed incorrectly or are omitted due to human error. Examples include parts installed incorrectly, missing parts, and the omission of necessary checks. … In comparison to many other threats to aviation safety, the mistakes of maintenance personnel can be more difficult to detect, and have the potential to remain latent, affecting the safe operation of aircraft for longer periods of time (ATSB 2008, p.vii).

Within Australia, the ATSB found that approximately 17% of reported aviation incidents that pose a safety risk could be attributed to the action of maintenance workers (ATSB 2007, p 28). This figure may underestimate the number of maintenance errors that pose a safety risk as an ATSB survey indicated that many errors are not reported.

> When Australian maintenance engineers were surveyed in 1998, over 60 per cent reported having corrected an error made by another engineer, without documenting their action, to avoid potential disciplinary action against the colleague (ATSB 2008 p. 29).

Internationally, in response to the safety risk posed by maintenance errors the International Civil Aviation Organization (ICAO) has recommended that countries require maintenance organisations to implement a safety management system. Whilst some Australian businesses have implemented a safety management system without regulatory compulsion, there is likely to be under-investment in safety management systems and the related human factors training because businesses do not capture the entire benefit of improved safety.

*Current regulations impose unnecessary compliance costs*

The current regulations impose unnecessary compliance costs on maintenance businesses because they impose requirements that are inconsistent with the operation of modern aircraft. This is particularly important in the maintenance of large aircraft that have a large number of avionic components, that is electronic, electrical, radio and instrument components. The current classification of licensed engineers will require a maintenance organisation to have up to three licensed engineers present to service a part on a hydraulic system with an electric pump, whereas in Europe such a task would only require one licensed engineer. Whilst it is possible for a single engineer to hold each of the relevant licence categories under the current regulations, only 32% of engineers hold 3 or more licence categories.

The current regulations also impose unnecessary compliance costs on individuals attempting to become a licensed aircraft maintenance engineer. The current regulations result in a number of individuals completing an apprenticeship and then sitting CASA licensing exams, however, because there is no mutual recognition between the TAFE delivered apprenticeship training and the CASA licensing exams, it results in individuals duplicating their study effort.

*Inconsistency with international regulations*

Australia's maintenance regulations are now inconsistent with many of our major trading partners in Europe and Asia, which have adopted European regulations. This inconsistency is expected to reduce competition within the aviation maintenance industry and if left misaligned over time, could result in a reduction in the competitiveness of Australia's aircraft operators and maintenance organisations.

If an Australian maintenance organisation is to perform work for international operators, they are currently required to comply with two sets of very different regulatory standards. For example, Qantas currently has a maintenance contract to service British Airways aircraft which requires it to comply with the British/ European regulations that are very different from the Australian regulations that it must comply with for its own aircraft. Greater harmonisation of the Australian maintenance regulations with the European regulations will increase efficiencies and potentially increase trade opportunities for Australian maintenance businesses. There are approximately 25 maintenance organisations that currently comply with both the Australian and European maintenance regulations.

Australian maintenance organisations or aircraft operators are unable to implement procedures to remove inconsistency between Australian and European regulations, this can only occur by governments changing regulations to remove or reduce inconsistency.

## Objective

The primary objective is to reduce the risk of aircraft accidents due to a failure in the maintenance of the aircraft. However, the regulations also seek to:

- maintain Australia's international competitiveness in the aviation industry;
- remove inconsistency with international regulations that can pose a safety risk and reduce competition; and
- reduce regulatory requirements where they are no longer justified.

## Options for improvement

After reviewing the current regulations, CASA is proposing changes to engineer licensing, safety management systems for maintenance businesses and the management of continuing airworthiness for aircraft operators.

*Engineer licensing*

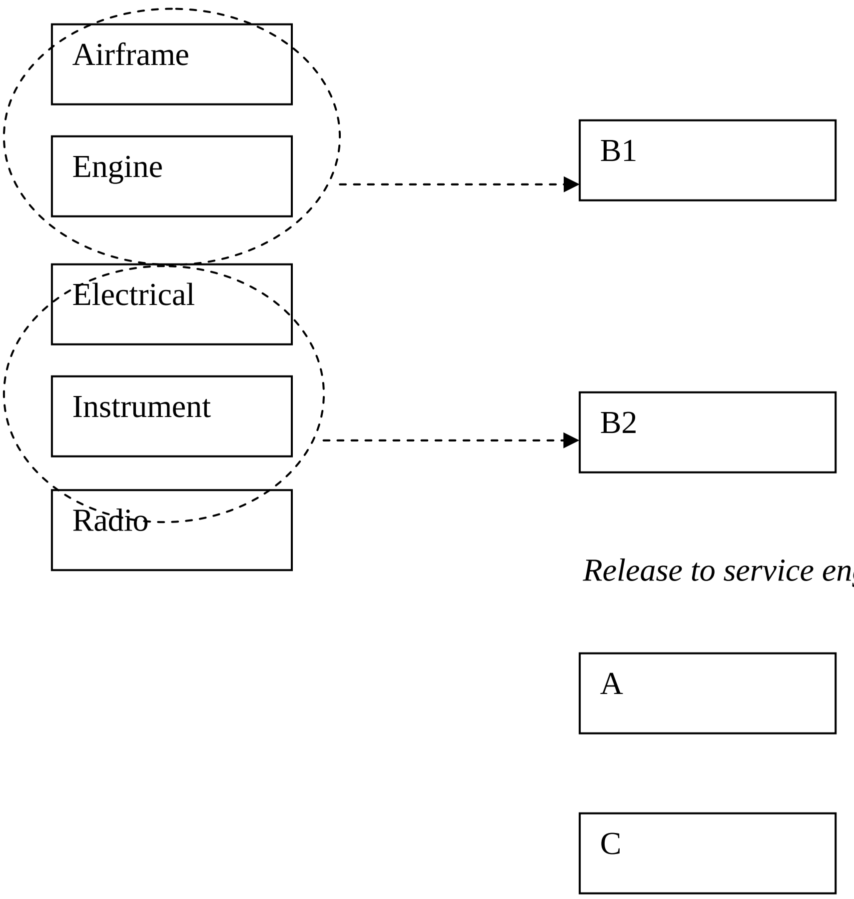
There are different methods for obtaining an initial licence in one of the five base licence categories. The most common method, at approximately 80%, is for individuals to submit a schedule of experience and to sit CASA exams to demonstrate theoretical knowledge. There is no accredited course for individuals to undertake to prepare for the exams and individuals must develop their own preparation methods. The other methods of obtaining a licence are recognition of defence force qualifications or recognition of international qualifications. To obtain an aircraft type rating requires the engineer to complete a course provided by a training organisation authorised by CASA.

The CASA licensing exams and schedule of experience will be replaced with competency based training administered by CASA approved training organisations. The completion of a diploma at an approved training organisation will demonstrate competency to enable the individual to be issued with a licence.

The other methods for obtaining a licence based on recognising defence force or international qualifications will remain largely unchanged. The licensing for specific aircraft types will also remain largely unchanged. The number of base licence categories will be reduced from five to two; and two ‘release to service’ engineer categories will be introduced which will align Australia’s licence categories with those operating in Europe (Figure 1).

**Figure 1:**

**Current Licence Categories** **Proposed Licence Categories**



In addition to their mechanical and power-plant privileges, the B1 licensed engineer will be permitted to certify maintenance work on electrical systems and avionics components that are line replaceable units requiring a simple test to prove serviceability - essentially units that can be unplugged and tested using in-built diagnostic equipment.

In addition, two new licence categories will be introduced to provide certification for the release of aircraft to service after the completion of maintenance.

- Category A Licence will allow for the certification and release to service after minor scheduled maintenance and simple defect rectification. This licence can be obtained after completing the training relevant for tasks permitted by the licence and obtaining 2 years of appropriate experience.
- Category C Licence will allow for certification after base maintenance is carried out on large aircraft by a Part 145 maintenance organisation and can be obtained after 3 years of experience as a B1 or B2 engineer or via an academic route coupled with type training.

*Aircraft operators*

Businesses operating regular public transport aircraft (passengers and/or cargo) will be required to create a division in their business responsible for the continuing airworthiness of aircraft, known as a Continuing Airworthiness Management Organisation (CAMO). The CAMO will be required to submit an exposition outlining how they will control the airworthiness of their aircraft and undertake periodic reviews to ensure the ongoing airworthiness of their aircraft. This requirement will ensure that there is a clear division of the business that is responsible for the continuing airworthiness of aircraft and reduce the risk of a non-airworthy aircraft being flown due to a failure in the division of responsibility.

The exposition will outline the systems that the business has in place to manage the airworthiness of their aircraft. Each aircraft has an agreed maintenance schedule and inspection program[1] and what the exposition will do is outline how the organisations will provide for these tasks. For example, it will outline what staff the organisation employs, their physical location and any contracted organisations it intends to use to maintain the airworthiness of their aircraft. A sample exposition is provided by the UK Civil Aviation Authority (CAA 2003).

*Maintenance organisations*

A maintenance organisation servicing regular public transport aircraft will be required to prepare an exposition outlining how it will carry out maintenance and will also be required to implement a safety management system (SMS). A safety management system is an organised approach to managing safety, the key elements including:

establishing safety policy at the company’s management level,

collecting safety information,

identifying safety hazards,

analysing safety risks,

performing safety investigations,

developing corrective actions,

providing safety training;

monitoring safety performance;

creating a continuous improvement environment; and

safety communication

[1] That will not be changing under these proposed regulations.

## Impact of the proposed changes

### Licensing of maintenance engineers

The changes to the licensing requirements will impact on individuals applying for a maintenance engineer's licence. Each year approximately 280 individuals are issued with a new maintenance engineer's licence.

The majority of individuals (79%) obtain a licence by submitting a schedule of experience and sitting the CASA licensing examinations, 7% through recognition of Australian Defence Force qualifications and 14% through recognition of a foreign licence. Given that the proposal will mainly affect the individuals obtaining a licence through the CASA examinations and schedule of experience, that method is the focus of this impact section.

The cost to society of obtaining a licence under the current CASA exam approach is a function of the amount of time individuals devote to preparing for exams, any tuition cost and government administration costs, which can be partly or wholly recovered through fees charged to applicants.

Currently there is no CASA endorsed or recommended course for gaining a base licence category and applicants are required to develop their own methods to prepare for exams. The most common method is self-study with some applicants enrolling in a non-accredited training course.

The majority of the licensing cost is borne by the individual, with each licence requiring 736 hours of self-study and private training costing an average of $980 (Table 1). The resource cost to administer the assessment system is estimated to be $4 438 per licence, which is borne by the applicant in terms of their time and the payment of assessment fees (Table 1). It is estimated that the total cost to society for each licence is $28 159 on average, $6.25m per year for 222 licences (Table 1).

**Table 1: Cost of the current and proposed licensing system**

| | Current licensing system | Proposed licensing system |
|---|---|---|
| Formal training | $0 | 550 hours at $30.7 = $16900 |
| Self Study | 736 hours at $30.7 = $22595 | 150 hours at $30.7 = $4605 |
| Private training | $1126 | $0 |
| Resource cost | $4438 | $11600 |
| Cost per licence* | $28159 | $28900 |
| Licences per year | 222 | 222 |
| Annual cost | $6.25m | $7.6m |

* Non-regional applicants

Source: Appendix A, pages 1 to 3.

*Proposed licensing*

Individuals will be required to demonstrate theoretical and practical competency to a training organisation approved by CASA. The completion of a diploma at a training organisation will be one way to demonstrate theoretical and practical competency.

There will be a small increase in the cost of obtaining a licence by completing a diploma and a change in the distribution of this cost. On average the diploma will require an additional 700 hours of study, after the completion of a Certificate IV trade course and have a resource cost of $11 600 to provide, which will be largely borne by government (Table 1).

There is likely to be a slightly higher cost impact for new engineers living in regional areas. The diploma element is estimated to cost each individual an additional $4750 to become licensed, as they incur increased living costs to attend a training organisation (Appendix A). With 53 applicants affected each year this will add an additional $251 750 to the annual cost of the proposed licensing system. It is also estimated that 10% of regional applicants will incur the additional cost to complete the equivalent of a Certificate IV at a cost of $11 750 per applicant and $58 750 for the 5 affected applicants.

The total cost of the proposed licensing system is $7.6m per year, which represents a cost increase of $1.35m on the current licensing system (Table 1).

## Benefits of the licensing proposal

*Introducing formal training*

Introducing a requirement for engineers to undertake formal training at an approved training organisation is likely to contribute to an improvement in aviation safety. The ATSB identified that a factor contributing to maintenance errors is a lack of training and/or skills on the part of the engineers undertaking the work (ATSB 1997).

The introduction of competency based training will reduce the probability of licensing an individual without the practical competencies required to perform the tasks of a licensed engineer. This should provide a safety benefit, however, it is difficult to quantify. A guide to the potential impact is provided by the failure rate for the current theoretical exams administered by CASA which is 15%.

A major benefit of the proposal is that with more formal training, licensed engineers will be more productive for their employers, which is reflected in the increased pay that employers currently offer employees who have completed additional formal training. On average employers pay an additional 12.6% for someone with a diploma qualification compared to someone with a Certificate level IV or III qualification (ABS 2010, Table 11). For the engineers undertaking the course each year this equates to a yearly productivity benefit of approximately $8 309 (Table 2).

When this benefit is aggregated over the 222 engineers who will participate in this training there is an estimated benefit of $1.8m each year (Table 2).

*Modernising licence categories*

The proposed regulation will reduce the number of core licence categories from five to two (Figure 1). The core licence categories determine the types of engineers that maintenance organisations require to undertake a certain task. The major benefit of reducing the number of base licence categories is that it will reduce the number of engineers required by regulation to perform certain tasks, and thereby improve efficiency.

This improvement is particularly important for modern aircraft with integrated mechanical and avionic systems. In aggregate, the scale of the efficiency improvement can be seen by comparing the number of engineers required by Australian maintenance businesses and European businesses subject to the licence categories that will be introduced in Australia. On average, Australian businesses are required to employ 13% more engineers per aircraft (Appendix A, p. 22).

After introducing these licence categories in UK there was an 8.6% improvement in efficiency (Appendix A, p. 22). If such an efficiency improvement was to be realised in Australia, this could generate a benefit of $15.7m per year for maintenance organisations (Table 2).

An additional benefit of sharing a common licence category with European countries and a number of non-European countries is that it will increase the ability of maintenance staff to transfer between countries. Each year approximately 40 licensed aircraft maintenance engineers migrate to Australia and obtain an Australian licence.

**Table 2: Benefits of the proposed engineer licensing system**

| | Returns to diploma training | Efficiency improvement from modern licence categories |
|---|---|---|
| Annual | 12.6% of annual wage = $8309 | 8.6% of annual wage bill of licensed engineers = $15.7m |
| Engineers trained annually | 222 | |
| Annual benefit | $1.8m | $15.7m |

Source: Appendix A, page 3 to 4

*Cost of changing licence categories*

The change to the licence categories is a low cost reform. The most significant cost is the difference in resource cost between training under the old licence categories and the new categories and the upfront development of training material for the new licence categories. This cost is included in the cost of providing the training, which is measured in the section above (Table 1).

A potential cost for some individuals is that the proposal reduces the options available to obtain a licence for a single category of work. In Figure 1 it can be seen that under the current regulations an individual could choose to become licensed in just one of the five categories. However, most current engineers choose to be licensed in multiple categories and only 22% are licensed in one category.

Existing maintenance engineers will not be disadvantaged by the licence category changes as they will be issued with a new licence that entitles them to undertake the same work. An engineer who currently holds a single licence qualification, for example to perform instrument work, will be issued with a new licence that is limited to that qualification, which in this case will be a B2 licence limited to instrument work.

**Maintenance businesses: cost impact**

*Exposition*

A maintenance organisation must develop and submit an exposition detailing how it will carry out maintenance on regular public transport aircraft. The exposition will outline the systems that the business has in place to maintain aircraft and aeronautical products that it is approved to maintain. For example, it will outline what staff the organisation employs and the physical location and equipment that the business has, the management systems it will use, and any contracted organisations it intends to use.

The cost of preparing the exposition may be minimised as the maintenance organisation can utilise material from their procedures manual required under existing regulations. The additional time to prepare the exposition is estimated to take a manager in a maintenance organisation two months at a cost of $22 500 per business and $5.6m in total for the 250 maintenance businesses that could be expected to apply for approval to service regular public transport aircraft. This is based on the time taken for four Australian businesses to comply with similar requirements operating in Europe.

*Safety Management System*

Maintenance businesses servicing regular public transport aircraft will be required to implement a safety management system. The upfront cost will include: understanding the requirements, development of a safety management dataset, a safety audit program and staff training in human factors, which focuses on how human decision making can affect aviation safety and the practices and procedures that staff can implement to improve safety. Ongoing costs will involve: investigation of safety incidents, undertaking a safety audit, training staff in human factors and for large businesses, the cost of employing a safety manager and safety analyst.

The costs of implementing a safety management system for a maintenance business will be similar to those incurred by aircraft operators that implemented safety management systems in 2009. The cost of implementing safety management systems for maintenance organisations in other countries also provides useful information on which to base Australian estimates.

The cost of implementing and running a safety management system will depend on the size of the business and Table 3 outlines the estimated cost by size of business. In aggregate for the 250 businesses, the upfront cost to implement a safety management system is estimated to be $0.9m and the ongoing cost is $13.1m to run the safety management system.

**Table 3: Costs of implementing a safety management system**

| *Business type* | *Upfront cost* | *Ongoing annual cost* |
|---|---|---|
| Sole trader | $3 312 | $1 116 |
| Less than 20 employees | $4 707 | $54 000 |
| 21 to 200 employees | $5 265 | $101 000 |
| 200+ employees | $5 265 | $200 000 |
| Ongoing HF training per annum | | $1.1m |
| Aggregate cost to business | $0.9m | $13.1m |
| CASA assessment | $3.4m | n/a |
| Total cost | $4.3m | $14.3m |

Source: Appendix A, page 4 to 6

**Aircraft maintenance businesses: estimated benefits**

The introduction of a safety management system is likely to lead to improvements in aviation safety and efficiency of aviation operations.

An evaluation of a safety management system introduced by Skyservice Airlines operating in Canada found that after introducing a safety management system there was a 22.5% reduction in ground safety incidents and a 5.86% reduction in safety hazards (Skyservices 2006). The UK also attributed a decline in maintenance incidents to the promotion of human factors awareness and the provision of safety training to maintenance businesses (CAA 2009, p.18).

If the safety management system was to reduce maintenance related aviation incidents by 22.5% this would generate a benefit valued at $3.5m each year (Table 4). If the impact was more reflective of the reduction in ground safety hazards found by Skyservice airlines of 5.86%, then this would generate an annual benefit of $0.9m (Table 4).

The reduction of maintenance errors not only provides a safety benefit, but it also improves the operational efficiency of maintenance businesses and airlines, by reducing the number of flight delays and cancellations caused by maintenance errors.

Each year it is estimated that maintenance errors result in 11 450 flight delays and 700 flight cancellations at a cost to society of $318m (Table 4). If a safety management system was to reduce delays and cancellations by 5.86%[2], this would generate a benefit of $18.1m each year, or $70m if the reduction was 22.5% (Table 4).

[2] The rate of reduction in safety hazards Skyservices (2006) found after introducing a safety management system.

**Table 4: Benefits of implementing a safety management system**

| | Accidents | Flight delays and cancellations |
|---|---|---|
| Number | 4 accidents, 2 fatalities | 67 000 delays, 4100 cancellations |
| Value | $47.3m | $1873m |
| Proportion attributed to maintenance | 0.3 | 0.17 |
| Value of maintenance related incidents | $15.8m | $318m |
| Value of a 5.86% improvement per year | $0.9m | $18.1m |
| Value of a 22.5% improvement per year | $3.5m | $70m |

Source: Appendix A, page 7 to 8

**Aircraft operators: cost impact**

*Continuing Airworthiness Management Organisation*

There are currently 35 businesses engaged in regular public transport that will be required to create a Continuing Airworthiness Management Organisation (CAMO) that will be responsible for ensuring the continuing airworthiness of their aircraft.

The creation of the Continuing Airworthiness Management Organisation in itself will not change the ongoing compliance costs as operators already employ staff to be responsible for ensuring the continuing airworthiness of their aircraft. However, aircraft operators will incur a cost to setup the CAMO and restructure some of their business functions to meet this requirement. Based on discussions with three Australian aircraft operators, CASA estimates that the average regular public transport operator would need to devote one senior manager to this task for one year, at a cost of $160 000 per business or $5.6m for the 35 businesses (Table 5).

The CAMO will be required to develop an exposition of how they will control the airworthiness of aircraft according to the maintenance instructions provided by the aircraft manufacturer and agreed to by CASA. This proposal will not change the airworthiness tasks that operators are required to undertake.[3] The cost of this requirement is the compliance cost to develop the exposition, which is estimated to cost $26 300 for the typical organisation; equivalent to two months salary of a senior manager. The total cost for the 35 businesses is estimated at $0.93m (Table 5).

**Table 5: Costs of implementing an airworthiness exposition and inspections**

| | Setup CAMO | Airworthiness exposition |
|---|---|---|
| Staff time (days) | 365 days for a senior manager | 43 days for a senior manager |
| Value of staff time | $160 000 | $26 300 |
| Number of businesses | 35 | 35 |
| Annualised cost | $5.6m (upfront) | $0.93m (upfront) |
| Total cost over 15 years (NPV) | $5.6m | $0.93m |

[3] These requirements are generally determined by the maintenance instructions released by the manufacturer and authorised by the relevant aviation safety authority.

*Aircraft Review*

There will be a requirement to have each aircraft physically inspected and its airworthiness documents reviewed annually to ensure that the aircraft is airworthy. The review and inspection can be undertaken every three years if it remains in the control of the same CAMO for that three year period. As regular public transport operators must have the CAMO functions performed within their business, it is assumed that the reviews and inspections will be done every 3 years for regular public transport aircraft.

The experience of European operators is that the physical inspections of the aircraft can be undertaken at the time of other scheduled maintenance and therefore do not result in any further out of service time for the aircraft. However, the additional labour cost needs to be considered.

Australian businesses have indicated that there will be a significant upfront cost to undertake the first review as this would require auditing all airworthiness records since the aircraft was new. However, on an ongoing basis aircraft operators will only have to audit the records since the last review and so subsequent reviews will be significantly quicker and less costly.

Based on an assessment from two major Australian airlines the initial review will take approximately 280 man hours; the equivalent of 7 weeks of full time work for 1 person per high capacity aircraft. For low capacity aircraft it is estimated to take 120 man hours, or 3 weeks for 1 person. For Australia's 350 high and 300 low capacity aircraft, this is estimated to cost $4.8m (Table 6).

From the experience of this requirement operating in the UK since 2003, subsequent reviews will take approximately 80 hours for high capacity aircraft and 24 hours for low capacity aircraft. This will impose a total cost of $1.26m every 3 years (Table 6) or $0.42m when annualised.

**Table 6: Cost of aircraft reviews**

| | Man hours | Staff cost per review[a] | Number of aircraft | Industry cost |
|---|---|---|---|---|
| *Initial* | | | | |
| High capacity | 280 | $9 971 | 350 | $3.5m |
| Low capacity | 120 | $4 273 | 300 | $1.3m |
| *Ongoing* | | | | |
| High capacity | 80 | $2 849 | 350 | $1m |
| Low capacity | 24 | $855 | 300 | $0.26m |

[a] Staff cost based on $30.7 per hour * 16% on cost.

*Overseas line maintenance*

Another change introduced for aircraft operators will be the requirement for all aircraft maintenance work to be carried out by an Australian approved maintenance organisation. At present some international aircraft operators have maintenance tasks performed by overseas maintenance organisations that are not required to be CASA approved.

The Australian businesses flying internationally use approximately 20 maintenance businesses in other countries that are not authorised by CASA. The most likely compliance response would be for these businesses to become CASA approved maintenance businesses. It is estimated that the cost of approval is $17 889 per business upfront and $0.54m when aggregated across the 20 businesses (Appendix A, p. 26).

**Aircraft Operators: estimated benefits**

The primary benefit of creating a continuing airworthiness management organisation and periodic aircraft reviews and inspections is to reduce the risk of an aircraft operator flying an aircraft that is not airworthy. The reviews will increase the probability of detecting failures to comply with airworthiness directives or scheduled maintenance requirements. The physical inspections will also ensure that the aircraft is free from obvious defects or damage that could affect its airworthiness.

The UK introduced the same aircraft review and continuing airworthiness management regulations in 2003. Since introducing these requirements for UK RPT operators in 2003, there has been a 5% reduction in the number of reported mechanically related incidents for regular public transport operators. There was an average of 308 for the years 1996 to 2002 compared to an average of 294 for the years 2004 to 2006 (CAA 2009, p. 9).

The UK experience provides a basis on which to assess the likely impact for Australia as the proposed regulations are almost identical to those introduced in the UK and the overall regulatory requirements applying to the UK and Australian aviation industry are similar as both countries are signatories to the Chicago convention.

In terms of the safety benefit within Australia, it is estimated that mechanical faults are the cause of 1/3 of accidents valued at $47.3m for regular public transport operations.[4] A 5% reduction in these mechanical faults could have a $0.79m safety benefit each year, or $6.9m over the next 15 years.

If the reduction was only half that experienced within the UK, that is a 2.5% reduction, then the value of this benefit would be $0.39m each year. Or conversely if the benefit was 50% greater than that experienced by the UK then the annual benefit would be $1.18m.

Additionally, the airworthiness exposition has the potential to reduce the ongoing cost for businesses to comply with CASA's airworthiness regulations. The exposition is outcome based with flexibility for businesses to demonstrate to CASA that their practices will ensure the safe operation of their aircraft. The lack of prescription will allow operators to develop the lowest cost acceptable means of compliance.

**Overall net benefit**

Overall the maintenance regulations are estimated to provide a small benefit to the aviation industry and the community overall, estimated at $155m over the next 15 years (Appendix A: Table A5) when evaluated at a 7% discount rate recommended by the Office of Best Practice Regulation (Australian Government 2007). When evaluated at a 3% discount rate the net benefit is $199m and $122m when evaluated using an 11% discount rate.

A time horizon of 15 years was chosen to reflect the minimum time that the regulations are likely to be in place. In part this time horizon was based on the current maintenance regulations being in place largely unchanged since 1988. There is however, uncertainty in predicting the life of these proposed regulatory changes. Reducing the time horizon from 15 to 10 years reduces the net benefit from $155m to $80m.

**Sensitivity Analysis**

The important parameters that affect the overall net benefit of this proposal are the efficiency improvements from the change in engineer licence categories, the productivity benefit from increased formal training of engineers, the estimated SMS efficiency improvement and the ongoing running costs of SMS. In aggregate they account for 95% of the benefits and costs.

Using the most pessimistic values for these parameters increases the costs by $44m and lowers the benefits by $51m, resulting in a net benefit of $65m (Appendix A: Table A6). Whilst this is a possible outcome of implementing these proposed changes, it is considered unlikely. Under this pessimistic scenario the changes would impose a cost on large maintenance businesses and aircraft operators, however, these businesses support the changes, which provides strong evidence that such a pessimistic scenario is unlikely. A number of these businesses have had direct experience complying with the regulations through their European work and therefore have a strong basis on which to assess the impact of the proposed regulations.

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[4] Appendix A page 25.

**Sensitivity analysis by parameter**

The values used in the sensitivity analysis depend on the source of information used to construct the cost and benefit estimates. The sources of information include surveys, the experiences of other countries implementing similar regulations and the reported cost estimates from affected Australian businesses.

For survey based estimates, the upper and lower bounds used in the sensitivity analysis were based on using the lower and upper bounds of a 95% confidence interval. For estimates based on the experiences of countries implementing similar regulations, the upper and lower bounds were based on 50% higher and 50% lower than the mean estimate. For estimates based on the views of Australian businesses, these businesses were asked for a worst case, best case and expected cost estimate. The upper and lower bounds were based on the worst and best case estimates.

## Consultation

CASA has developed this regulatory proposal working with the aviation industry over a five year period. A notice of proposed rule making was published in 2006 (CASA 2006) outlining the major changes in order to seek feedback from stakeholders. 85 unique responses were received, which CASA has considered and will publish along with a CASA response in a notice of final rule making.

Of the respondents that stated a view on the proposed changes, 24% accepted the proposals, 31% accepted the proposals but thought they could be improved, and a further 31% would support the proposals with changes. 15% would not support the proposals under any circumstances. Table 6 includes the number of responses to the individual changes.

**Table 6: Responses to the proposed regulatory changes**

| | Licensing categories (Part 66) | Training organisations (Part 147) | Maintenance business (Part 145) | Aircraft Operators (Part 42) | Total |
|---|---|---|---|---|---|
| Acceptable | 11 | 23 | 18 | 17 | 69 |
| Acceptable, but improvable | 27 | 15 | 28 | 21 | 91 |
| Acceptable with changes | 36 | 13 | 17 | 22 | 88 |
| Not acceptable | 20 | 8 | 7 | 7 | 42 |

Most of the comments were covered during development of the consultation drafts of the proposed regulations which were released in November 2009. The responses to the consultation draft revealed that very few matters that required further clarification and subsequent versions of the drafts have addressed those remaining matters.

The most significant negative response to the proposed changes released in the 2006 Notice of Proposed Rule Making (Table 6) related to the license category changes and in particular, the inclusion of avionic certification for the B1 license category, with 25 individuals commenting on this issue. CASA has considered these views but not changed the proposal because of the importance of harmonising with European regulations and the creation of license categories that align with the maintenance tasks required on modern aircraft. In addition, the B1 license will be issued based on competency to ensure that only qualified engineers are licensed.

There was significant opposition from the Australian Licensed Aircraft Engineers Association (ALAEA) itself and its members to these proposed regulations. A total of 1108 pro-forma objections were received from ALAEA members and these were counted as a single response in

Table 6. The ALAEA strongly opposed pilot maintenance, license training provisions and terminology. CASA has carefully considered each of the objections and responded to each individually in a summary of consultation response document that will be published on the CASA website along with this regulation impact statement. CASA has adopted some of the ALAEA's comments such as changing the terminology used to describe aircraft engineers.

In contrast, the major airlines were supportive of the changes with Qantas Engineering stating that they endorse and support the proposal.

CASA has responded to the consultation process by making specific implementation changes to the proposal. For example, the original proposal was to apply to all aircraft operators (approximately 1000 businesses), however, in response to the consultation CASA has decided to initially apply the regulations affecting aircraft operators only to regular public transport operators (currently 35 businesses operating aircraft) with a two year transition period. The implementation date was also extended from November 2010 to June 2011. More detailed changes were made, for example the original proposal based the requirement to replace components on the basis of the aircraft manufacturer's recommended life limits, however, industry advocated for it to be based on the approved type certification.

**Implementation and Review**

The changes will be formally implemented by inserting Parts 42, 66, 145 and 147 into the Civil Aviation Safety Regulations.

> Part 42 – Continuing Airworthiness – This Part establishes the measures that operators of regular public transport aircraft are required implement to ensure that airworthiness is maintained, including maintenance. It also specifies the conditions to be met by the persons or organisations involved in such continuing airworthiness management.
>
> Part 66 – Maintenance Personnel Licensing – This Part establishes the requirements for the issue of an Aircraft Maintenance Licence, other permissions and the conditions of validity and use of these licences and permission, for aeroplanes, helicopters and other specialised maintenance tasks.
>
> Part 145 – Approved Maintenance Organisations – This Part establishes the requirements to be met by an organisation to qualify for the issue or continuation of an approval for the maintenance of aircraft and aeronautical products.
>
> Part 147 – Maintenance Training Organisations – This Part establishes the requirements to be met by an organisation to qualify for the issue or continuation of an approval to conduct training that leads to a Part 66 licence.

The regulations will be effective from 27 June 2011, but will contain an extended transition period to minimise the cost to businesses of this regulatory change.

*Transition arrangements and implementation assistance*

A two year transition period will be in place for regular public transport aircraft operators, maintenance organisations providing maintenance services to regular public transport operators and training organisations. A four year savings period will allow licensed engineers who wish to complete their training under the existing CAR31 licensing system.

Regular Public Transport aircraft operators will have two years to become compliant with the Part 42 requirements. CASA will work with the 35 operators[5] to develop an exposition manual over this period and publish a detailed sample manual and provide IT tools assisting businesses to comply.

[5] New operators after June 2011 will be required to meet the new requirements in order to obtain a certificate to operate.

The sample exposition manual will be similar to that published by the UK Civil Aviation Authority (CAA 2003).

Existing maintenance organisations registered under the existing regulation (CAR 30) will have two years to become compliant with Part 145 if they wish to service aircraft operated or aeronautical products required for regular public transport operations.[6] The major requirements will be the development of an exposition, the implementation of a safety management system and human factors training for their workforce. CASA will assist in the implementation by providing practical guidance on how to develop and implement a safety management system, along with human factors training. CASA will work with the 250 maintenance organisations expected to apply for a Part 145 approval to develop an exposition over this period and will publish a detailed sample exposition to help businesses comply.  The sample exposition will be similar to that published by the UK Civil Aviation Authority (CAA 2003).

Existing licensed maintenance engineers will be granted a CASR Part 66 licence equivalent in maintenance scope to their current licence.  For new applicants a four year transition period will operate during which applicants can become licensed under either the existing or the new Part 66 system. This 4 year period has been set to correspond with the 4 year apprenticeship cycle, to allow for anyone who has commenced their training under the existing system to complete this process without being disadvantaged.

The transition period for training organisations will depend on the type of training the organisation provides. Training organisations that provide aircraft specific courses will have two years to become a Part 147 organisation. For organisations providing training that leads to an A, B1, or B2 licence category, an application under CASR Part 147 will be required post June 2011. Four organisations have already met requirements equivalent to Part 147 and offer approved diploma courses.

*Review*

The regulatory changes will be subject to a formal post-implementation review commencing not later than 2 years after they are fully implemented. There will be constant monitoring of the performance of the maintenance industry to examine how the new regulations are performing. This monitoring will be undertaken through the CASA field offices and through the Standards Consultative Committee and a technical working group, both of which contain industry and CASA staff.

## Conclusion

The current maintenance regulations were originally developed in 1947 and updated constantly since that time with the last major update and re-issue in 1988. The regulations have failed to fully account for technological progress and best practice methods developed from recent operational experience. The current regulations impede the efficiency of aircraft maintenance, imposing unnecessary compliance cost on business and potentially compromise safety. In addition, the regulations are not risk based, and target all activities equally regardless of their contribution to aviation safety risk.

The proposed regulations are an attempt to incorporate the lessons learnt from recent operational experience and align the regulations with the technology of modern aircraft. The proposed changes are a product of a long and extensive consultation period with business and affected stakeholders. CASA modified the proposed regulations published as part of the notice of proposed rule making process to address industry concerns, where feasible.

[6] Operators choosing not to service RPT aircraft after June 2013, will maintain their CAR 30 certification and will be able to maintain aircraft not used in RPT operations until June 2015.

It is important to note that the regulatory proposal is risk based, with the strongest requirements placed on operations that pose the greatest safety risk and therefore the largest potential gains, that is regular public transport aircraft.

The impact analysis shows that overall the proposed changes will provide a net benefit to society. This finding largely stems from the positive experiences of other countries that have implemented the changes proposed in these regulations. In distributional terms the proposal will not impose significant costs on certain groups without compensating benefits for that group. For example, whilst the safety management system requirements will impose some costs on certain businesses to implement, there will be productivity improvements which these businesses will benefit from. Indeed, a number of businesses have already implemented such systems without regulatory compulsion.

The proposed regulations include a substantial transition period and arrangements to minimise the implementation cost. Implementation costs will also be minimised by the long time period over which CASA has foreshadowed these regulations, and which has allowed a number of businesses to become compliant already.

As a final check on the beneficial impacts of the proposal, the regulations will be reviewed after two years of implementation.

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# Appendix A: Cost Benefit Analysis

### Cost of training aircraft maintenance engineers

Over the last three years 667 engineers obtained a licence by submitting a schedule of experience and sitting CASA licensing exams. For the base case it has been assumed that an average of 222 engineers will be licensed under this approach annually over the next 15 years.

*Costs of current licensing*

The major cost of the current licensing system is the amount of time that applicants spend studying for the CASA licensing exams. On average applicants spend 40.5 hours preparing for each exam, which is derived from a survey of licence applicants from 2009 (Table A1).

**Table A1: CASA Licensing Applicant survey 2009**

| | Mean Response | Standard Deviation |
|---|---|---|
| Average time spent preparing for each exam | 40.5 | 24.04 |
| Proportion of exams for which a course was undertaken | 0.12 | |
| Sample size | 50 | |
| Response rate | 79% | |

Note: Sample size: 63.

The average licence requires 18.4 exams to be completed which results in a total of 4085 exams being sat each year for the 222 applicants. A total of 163 392 hours are therefore spent preparing for exams each year, or an average of 736 hours per licence applicant.

When valued at the average mechanical engineering wage of $30.7 per hour[7] the total cost of study time for each applicant is $22 595 or $5.02m when aggregated over the 222 licences issued each year.

Another cost component for the current licensing system is the use of courses to help students prepare for the licensing exams, with 12% of exams involving the applicant undertaking a course (Table A1). Whilst the average study time preparing for the course includes the time spent participating in a course, there is also the resource cost involved in providing it. The average cost for a course has being assumed to be $500[8], which provides a total cost of $0.25m each year for the 500 courses undertaken, or $1126 per license.

The assessment of theoretical knowledge and practical experience has a resource cost in terms of sitting exams and the assessment of a schedule of experience.

- Of the 4085 exams conducted each year the average duration is three hours.[9] When valued at the $30.7 hourly wage rate, this provides an annual cost of $0.38m. An estimate of the resource cost to provide the exam is the $100 charge CASA recovers from each exam applicant to cover the resource cost of running the exam system. This $100 estimate provides an annual resource cost for the 4085 exams sat each year of $0.41m.

[7] ABS 2009, Mechanical Engineering Trades hourly wage rate
[8] Based on the Queensland Aerospace College fees, which is the largest provider of these courses.
[9] The 3 hours represents the exam time, which is a maximum of 3 hours and travel time to and from the exam centre.

- Of the 222 licences issued each year there is an average cost of $903[10] to assess the schedule of experience, providing an annual cost of $0.2m.
- The resource cost of the assessment process is $0.98m, or $4 438 per licence.

Aggregating the costs associated with self-study time ($5.02m), courses undertaken for exam preparation ($0.25m) and the conduct of the exams themselves ($0.98m), gives a total cost for the current licensing system of $6.25m per year, or $28 159 per licence.

This total cost estimate is based on the mean estimate from a survey (Table A1) that is subject to sampling variation. If the actual time taken to prepare for the exams was the lower bound of a 95% confidence interval, the preparation time would be 33.8 hours per license and the annual cost of the current system would be $5.5m. If the actual time taken to prepare for exams was the upper bound of a 95% confidence interval, it would derive an estimated time of 47.2 hours and a total annual cost for the current licensing system of $7.2m.

*Cost of the proposed licensing system*

Under the proposed licensing system the training organisations authorised by CASA will provide a diploma course or equivalent that licence applicants must complete in order for CASA to issue them a licence.

A number of training organisations are already authorised by CASA and have approved diploma courses on offer. The average additional duration to complete a diploma after obtaining a Certificate IV is 550 hours, which includes theoretical teaching and the assessment of theoretical and practical competency.

In addition to the 550 hours of formal training time, applicants will also devote self-study time for completing assignments and preparing for exams. Based on information provided by one training organisation that currently provides the diploma course it is estimated that applicants will devote 10 hours per week, or 150 hours for the complete diploma to self-study.

With 222 applicants each year, the 150 hours per course when valued at the $30.7 hourly wage will generate a total opportunity cost of $1.02m each year.

The resource cost of providing the courses can be estimated in two ways:

- Payments that technical colleges receive for providing the diploma course; or
- The fee charged by private training organisations to full-fee paying students

One complication with the private training organisation method is that the current registered organisation only provides a diploma course that incorporates the Certificate IV units to full-fee paying students. However, the proposed licensing system only imposes the additional cost of moving from a Certificate IV to a diploma and it is important to isolate this additional cost.

It is possible to estimate the time of the additional diploma element of the approved technical college courses based on the hours involved in both courses. A Cert IV course requires 1350 hours and the diploma requires a further 550 hours. The additional diploma time is therefore 29% of a combined Certificate IV diploma course. When this 29% is applied to the $40 000 fee charged by a private institution for providing a combined Certificate IV and diploma course, it derives an estimated cost of $11 600 for the additional diploma element[11].

Using the information on private course fees of $11 600, it is estimated that the 222 diplomas will involve a $2.58m resource cost each year. It is important to note that by basing the cost estimates on the fees charged by a private business, the resulting resource cost estimate will capture all costs

[10] The total assessment cost is based on the number of base categories applied for with the licence (figure 1), with a $390 fee per base category. On average there are 514 base categories issued for the 222 licences each year, deriving an average cost of $903 per licence.

[11] Aviation Australia course fee for a combined diploma certificate IV course.

incurred by the training organisation to provide the training, including the cost of becoming CASA approved.

*Additional cost for engineers in regional areas*

There is likely to be a slightly higher cost impact for new engineers living in regional areas to access an authorised training organisation, however, these training organisations have developed distance and online learning methods to reduce the impact on those students living in regional and rural areas. Aviation Australia who currently provides the diploma course, provides up to 57% of their course through distance learning methods.

Over the last 3 years there were 667 newly licensed engineers, of which 159 (or 53 per year) were from a regional or rural area[12].

It is estimated that the proposed licensing system will cost an additional $4750 per applicant for the 53 regional applicants each year to complete the additional diploma element. The additional diploma element is 550 hours, of which it is estimated (based on discussions with two current training organisations) that the applicants must complete 236 hours of study at a training institution, with the remaining 314 hours being undertaken by distance learning methods and online assignments and assessments. The 236 hours, which is the equivalent of 8 weeks full-time study, is estimated to cost the regional applicant an additional $350 per week in living expenses ($2750 in total) based on the experiences of 15 recent regional licence applicants. The applicants will also incur a transport cost to make two trips to the training organisation at a cost of $1000 per trip, resulting in a total additional cost of $4750 per applicant. Each year for the 53 applicants this will cost $251 750.

There will also be an impact on those licence applicants that currently become qualified and licensed without completing a Certificate IV trade course. CASA estimates that 10% of the regional applicants (or 5 per year) utilised on the job training to become qualified and subsequently licensed without completing a certificate IV.

It is therefore estimated that 5 regional applicants each year will incur the additional cost to complete the equivalent of a Certificate IV. It is estimated to cost each individual an additional $11750 to become licensed, or $58 750 each year for the 5 applicants. The applicant must complete 1350 hours of study to complete a Certificate IV of which it is estimated that 43% (or 579 hours) must be completed face to face at a training institution. At an average of 30 hours per week this is the equivalent of 19 weeks full-time study, at a cost of $350 per week this will total $6750. The applicant will also incur a transport cost to make five trips to the training organisation at a cost of $1000 per trip, resulting in a total cost of $11 750 per applicant.

Aggregating the opportunity cost of applicant's time and the resource cost of providing a diploma (or equivalent) provides an estimated cost for the proposed system of $7.6m each year. When compared to the costs of the current licensing system this results in a cost increase of $1.35m each year.

The proposed licensing system will involve the applicants undertaking an additional 550 hours of formal training to achieve a diploma level qualification. The additional formal training will improve their productivity at work. The productivity benefit can be seen by the fact that employers are willing to pay higher wages to staff with a diploma qualification. The ABS estimates that employers pay an additional 12.6% for staff with a diploma than staff with a Certificate IV or III qualification.[13]

The benefit to society of such a productivity improvement depends on the characteristics of the market for licensed engineers. It is known that the average wage is $60 663 per year[14] and that

[12] Defined as Outer Regional, Remote and Very Remote on the ABS AGSC classification (ABS 2010a).
[13] ABS 2010.
[14] Based on the $30.7 hourly wage and an average working week of 38 hours.

licensed engineers are paid approximately 8.7% more than an unlicensed maintenance engineer (FairWork 2009). Therefore, the base wage for licensed engineers is assumed to be $65 941 and that this wage applies to the 222 engineers applying for a licence each year.

With inelastic supply, the benefit to society of a 12.6% productivity improvement is simply the 12.6% change in wage multiplied by the 222 new licensed engineers each year, deriving an estimated annual benefit of $1.84m. This estimate is based on a point estimate derived from an ABS survey and is subject to sampling variation. The annual benefit would be $1.76m if the true estimate was 2 standard errors below the mean estimate derived from the survey. Or the annual benefit would be $1.93m if it was two standard errors above the mean estimate.

The estimated benefit is also dependent on the number of engineers assumed to become licensed in the future. If the number was 10% lower than that observed over the last three years, the benefit would be $1.7m each year. Conversely if it was 10% higher the benefit would be $2.0m.

**Benefit of the proposed licence category change**

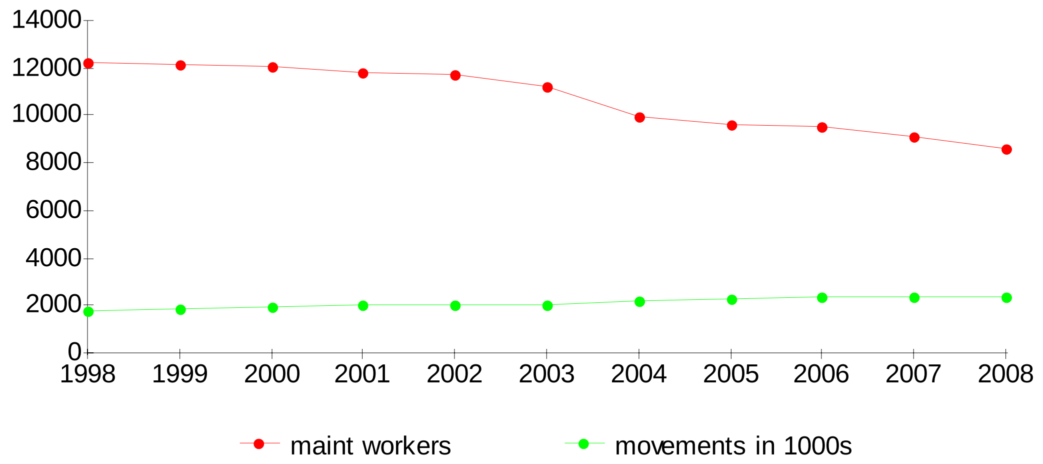
The change in licence categories will result in businesses requiring fewer licensed engineers to be present and certify maintenance work. For example, under the current regulations a business would require both a licensed electrical and mechanical engineer to replace a vacuum switch on a hydraulic system, whereas under the proposed system only one engineer will be required.

In aggregate the magnitude of the efficiency improvement can be seen by comparing the number of engineers required by Australian maintenance businesses and European businesses subject to the proposed regulations. On average, Australian businesses are required to employ 13% more licensed engineers per aircraft. In the UK 8695 licensed engineers are required for 21 000 registered aircraft (CAA, 2010b) (or 0.414 engineers per aircraft), compared to Australia in which 6 467 licensed engineers are required for 13 460 registered aircraft (or 0.48 engineers per aircraft). On these measures, the UK system represents a 13% efficiency improvement on Australia.

The estimated efficiency improvement is supported by evidence showing a reduction in total maintenance staff after the introduction of the licence categories in the UK in 2003, without any reduction in aircraft usage (Figure A1).

The experience of the UK is likely to provide a strong basis for assessing the proposed regulations as the B1, B2, A and C license categories are identical to those operating in the UK. Moreover, the licence categories that existed in the UK prior to 2003 were similar to those that currently exist in Australia.

**Figure A1: Maintenance Workers employed by UK Airlines and Aircraft movements** (source: UK 2009, p.46).



Excluding 2003, the average reduction in maintenance workers was 2.6% each year, whereas in 2003 the reduction was 11.2%, or 8.6% greater than the trend reduction. If an 8.6% efficiency improvement was to be realised in Australia, this could generate a benefit of $15.7m per year for maintenance organisations. That is 8.6% of the current wage bill[15] for the 2 589 licensed engineers employed in the 250 businesses maintaining regular public transport aircraft. However, it is expected that this benefit will only start to accrue after the transition period is complete.

The change in the number of workers is consistent year on year, varying only by 2.5% on average with a standard deviation of 5%. The 11% change in 2003 is therefore more than 2 standard deviations from the mean change over other years. This provides strong evidence that the change in 2003 was not statistical noise and was caused by the change in the regulations. However, there is a degree of uncertainty around this estimated impact as it only is only based on one observation, ideally such an estimate should be based on observations of many countries implementing the regulations. In the absence of such data, it is important to highlight how different outcomes could impact on the estimated benefit of this change.

If the improvement in Australia was only 50% of that achieved in the UK, the annual benefit would be $7.8m, or if it was 50% greater than experienced by the UK the annual benefit would be $23.5m.

**Costs of introducing a safety management system for maintenance organisations**

Overall the expected upfront cost for businesses to implement the safety management system is estimated at $0.9m when aggregated across maintenance businesses of all sizes. The ongoing cost is estimated at $13.1m per year for all businesses, which equates to $108m in present value terms based on a 7% discount rate and a timeframe of 15 years. Box A1 outlines the construction of these cost estimates.

These cost estimates reflect the average cost based on the views of 4 businesses operating regular public transport aircraft who implemented a safety management system in 2009. If the cost estimates were to be based on the highest reported cost, rather than the average reported cost, the estimated upfront cost would be $2.7m and the annual ongoing cost $16.4m. Based on the lowest reported costs, the estimated upfront cost would be $0.7m and the annual ongoing cost $10.7m.

There will be an additional resource cost for CASA to assess the proposed safety management system of the business as part of the business's application to service regular public transport aircraft. It is estimated that it will take CASA 90 hours on average to assess the applications of the 250 businesses, deriving an upfront cost of $3.4m when valued at $150 per hour.

One of the ongoing costs involves the maintenance business providing 1 day per year of human factor training for all maintenance engineers. The safety manager within the business will provide the training and the major cost of providing it is the opportunity cost of the engineers' time.

The exact number of employees per maintenance business is not known, however, the ABS publishes the number of maintenance engineers employed in the aircraft repair industry, excluding the defence force, which in 2006 was 9 871 (ABS 2006). It is assumed that 40% of those engineers are employed in the 250 maintenance businesses that would potentially apply to become a Part 145 organisation.[16] At an average wage of $285 per day[17], the 1 day of human factor training provided each year to 3948 engineers will have an opportunity cost of $1.1m across those maintenance businesses.

[15] The wage bill is the product of the licensed engineer wage $30.7 * 16% on-cost * 38 hours * 52 weeks * 2589 engineers = $182m.

[16] The 250 businesses estimated to apply for a Part 145 approval represents 40% of the currently approved maintenance businesses and it is assumed that they employ 40% of the aircraft engineers.

[17] $30.7 hourly wage * 8 hours * on cost of 16%.

**Box A1: Safety management system compliance costs by size of business**

*Upfront costs*

Compliance for sole traders would require an understanding of the safety management system principles, human factor training and the development of a safety dataset. This would require 2 days of time to understand SMS principles and a further 2 days training in human factors, and a 1/2 day to setup an excel spreadsheet for the safety dataset. For individual sole traders, this would generate an upfront cost of $3312, based on 2.5 days of time valued at the average salary of $120 000 per year and $800 in human factor training from an external provider. In aggregate for the estimated 79 sole traders this would generate a total cost of $198 000. This cost may be reduced by the CASA requirements being similar to the processes required under State and Territory OH&S laws that these businesses must already comply with.

For small/medium maintenance organisations employing less than 20 people, the time cost will be similar to sole traders with the addition of 2 days in time for developing staff training material and an investigation and audit program for the organisation. For individual small organisations this will cost 2.5 days valued at an average salary of $120 000 or $1395 per business. When this additional cost is added to the $3312 cost for sole traders, this generates a cost of $4707 per business. In aggregate for the 107 small businesses this will cost a total of $418 000.

For large businesses employing up to 200 people that are not aircraft operators, the time cost will be similar to small/medium business, however, the implementation of a safety management system will require an additional one day valued at $558 for developing staff training material and an investigation and audit program for the organisation. When the additional $558 is added to the $4707 cost for small/medium organisations, this derives a total cost of $5265 for individual large organisations that are not aircraft operators. In aggregate for these 52 businesses this will cost a total of $23 200.

For very large businesses employing more than 200 staff, that are not aircraft operators, the time cost will similar to large businesses and is therefore estimated at $5265 per business. In aggregate for these 6 businesses this will cost a total of $26 790.

In addition, there are 6 maintenance organisations employing more than 200 people that operate aircraft who have already implemented a safety management system for the aircraft operation side of their business. For these organisations, it would take 5 days to extend the SMS to the maintenance organisation side of their business generating a total cost of $2791 per business or $16 744 in total for the 6 businesses in this category.

*Ongoing costs*

For sole traders, there will be ongoing requirement to demonstrate an understanding of the principles of safety management systems and human factors, at cost of 1 day per year and 1 day to record any safety incident in the database and comply with a safety audit.
The total cost will be 2 days per year valued at a salary of $120 000, generating a total cost of $1116 per business or $88 000 in total when aggregated across the 79 sole traders.

For small/medium organisations the ongoing costs will be more significant, there will be more safety incidents to report, which will need to be investigated, ongoing risk assessments will be required for the assessment of safety risks, developing means of reducing risks and training staff in safety. It is estimated that this will be equivalent to 40% of the full-time workload for a person nominated as a safety manager within the organisation. When valued at a salary of $135 000, this will cost small/medium businesses approximately $54 000 each year. When this cost is aggregated across the 107 small/medium businesses it will generate an ongoing cost of $5.8m.

For large maintenance organisations employing up to 200 staff that do not operate aircraft, will be required to perform the same ongoing tasks of a medium sized business, but the additional employees will generate more safety incidents and risks to be assessed and staff to be trained. It is estimated that this will require 75% of the full time workload of one person, valued at $101 000 for each business. When this cost is aggregated across the 52 businesses in this category it will generate an ongoing cost of $5.3m.

For very large businesses employing more than 200 staff will be required to employ a full-time safety manager and a part-time safety analyst, at a salary of $135 000 and $75 000 respectively. This will cost $200 000 each year, or $1.2m when aggregated across the 6 businesses in this category.

The ongoing cost will be lower for very large businesses that operate aircraft due to the synergies with the SMS requirements on their aircraft operations. This would lower the cost to one full-time equivalent safety manager at cost of $135 000 each year. And $0.8m when aggregated across the 6 businesses in this category.

**Benefits of the safety management system**

*Aviation safety*

An evaluation of a safety management system introduced by Skyservice Airlines in Canada found that there was a 22.5% reduction in ground safety incidents and a 5.86% reduction in safety hazards. The UK CAA has found that aviation safety has improved since human factors training was introduced for aircraft maintenance organisations and aircraft operators (CAA 2009, p.18). This provides evidence on the possible impact of introducing safety management systems and human factors training for aircraft maintenance businesses within Australia.

In considering the possible impact within Australia, it is important to isolate the aviation accidents that can be attributed to maintenance errors that could be avoided by a safety management system.

The ATSB estimates that each year for regular public transport aircraft there are approximately 4 accidents, resulting in 2 fatalities and 4 written-off or substantially damaged aircraft (ATSB 2009, p. 10-13). Using a value of statistical life of $3.5m and an average aircraft value of $10m these accidents result in a $47.3m cost to society each year. The ATSB (ATSB 2007, p. 67) estimates that

33% of accidents can be attributed to mechanical failure resulting in annual value of $15.8m for mechanically related crashes.

If the safety management system was to reduce these mechanically caused accidents by a similar proportion to the reduction in ground safety incidents found by the Skyservices evaluation of 22.5%, this would generate a value of $3.5m each year[18]. If the improvement in safety was reflective of the reduction safety hazards found by the Skyservices evaluation of 5.86% than the benefit would be $0.9m each year.

*Aviation efficiency*

The reduction in maintenance errors not only provides a safety benefit, but it also improves the operational efficiency of maintenance businesses and airlines. Maintenance errors can lead to delayed or cancelled flights, that can cost an airline approximately $18 500 per hour for a delayed flight and $152 000 for a cancelled flight (ATSB 2008, p.2)[19].

The BITRE estimates that for the major airlines there are approximately 67 000 flight delays and 4100 flight cancellations each year, however, the BITRE does not identify how many are caused by maintenance errors (BITRE 2010, p. 10). A reasonable approximation is the 17% of safety/technical incidents caused by maintenance errors (ATSB 2007, p 28). This is a similar proportion of flight delays and cancellations caused by maintenance errors in the US of 14%. Based on the 17% estimate there would be approximately 11 450 flight delays and 700 flight cancellations each year caused by maintenance errors.

If the delays were to be one hour on average and valued at $18 500 per hour with cancellations valued at $152 000, then maintenance caused delays and cancellations would be valued at $318m each year.

If the safety management system was to reduce flight delays and cancellations caused by maintenance errors by a similar rate to the reduction in safety hazards found by the Skyservices evaluation of 5.86%, this would generate a benefit of $18.1m each year.[20] The benefit would be $70m each year if the improvement was based on Skyservices estimated reduction in ground safety incidents of 22.5%. Based on discussions with three Australian aircraft operators and to be conservative, the net benefit estimate reported in Table A5 is based on the lower estimate of 5.86%.

**Aircraft operators**

*Overseas Maintenance*

International aircraft operators currently use approximately 20 maintenance businesses in other countries that will require CASA approval. The approval process will involve a cost for the business to prepare the application and for CASA to assess that application.

It is estimated that the CASA assessment time will be approximately 90 man hours per business based on the experiences of CASA assessing the maintenance applications from Australian businesses. When valued at $150 per hour this will involve a cost of $0.27m in total for the 20 businesses.

It is difficult to estimate with accuracy the amount of time that the business will devote to seeking approval. It is likely that the costs will be minimal because they are established businesses (for example, British Airways, Cathay Pacific and Boeing). These companies will have documented procedures, including a SMS that are likely to meet CASA's requirements. It has being assumed that the business would devote 1 month of a senior manager's time to preparing the application, which is the average time that three Australian maintenance businesses devoted to preparing for a CASA approval. When valued at a salary of $160 000, this would equate to $13 300 per business or

[18] That is, 22.5% of $15.8m.
[19] Values converted from US dollars at a 0.92 exchange rate.
[20] That is 5.86% of $318m.

$0.27m in total for the 20 businesses. If 2 months of senior manager's time was required, this would increase the cost to $0.54m, whereas if only 0.5 of a month was required the aggregate cost would be $0.13m

In total, the cost of the approval including the estimated business cost and CASA assessment time will be $0.54m or an average of $17 889 per business.

## Table A5: Net Present Value Calculations $m

| **Benefits** | Y1 | Y2 | Y3 | Y4 | Y5 | Y6 | Y7 | Y8 | Y9 | Y10 | Y11 | Y12 | Y13 | Y14 | Y15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Productivity benefit of providing better training | 0.0 | 0.0 | 0.0 | 0.0 | 1.8 | 3.7 | 5.5 | 7.4 | 9.2 | 11.0 | 12.9 | 14.7 | 16.6 | 18.4 | 20.2 |
| Efficiency benefit from licence category change | 0.0 | 0.0 | 0.0 | 0.0 | 15.7 | 15.7 | 15.7 | 15.7 | 15.7 | 15.7 | 15.7 | 15.7 | 15.7 | 15.7 | 15.7 |
| SMS safety improvement | 0.0 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| SMS efficiency improvement | 0.0 | 18.1 | 18.1 | 18.1 | 18.1 | 18.1 | 18.1 | 18.1 | 18.1 | 18.1 | 18.1 | 18.1 | 18.1 | 18.1 | 18.1 |
| Safety benefit from Part 42 | 0.0 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Total undiscounted benefits | 0.0 | 19.8 | 19.8 | 19.8 | 37.3 | 39.1 | 41.0 | 42.8 | 44.6 | 46.5 | 48.3 | 50.2 | 52.0 | 53.8 | 55.7 |
| Discount factor | 1.0 | 0.9 | 0.9 | 0.8 | 0.7 | 0.7 | 0.6 | 0.6 | 0.6 | 0.5 | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 |
| Total discount benefits | 0.0 | 18.4 | 17.1 | 15.9 | 27.9 | 27.2 | 26.5 | 25.8 | 25.0 | 24.2 | 23.4 | 22.6 | 21.8 | 21.0 | 20.2 |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| **Costs** | | | | | | | | | | | | | | | |
| Diploma training of engineers | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 |
| Maintenance exposition | 5.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| SMS costs | 4.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 |
| Set up CAMO | 5.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Prepare Exposition | 0.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Aircraft Reviews | 4.8 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| Overseas maintenance | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | | | | | | | | | |
| Total undiscounted costs | 23.1 | 16.1 | 16.1 | 16.1 | 16.1 | 16.1 | 16.1 | 16.1 | 16.1 | 16.1 | 16.1 | 16.1 | 16.1 | 16.1 | 16.1 |
| Total discounted costs | 23.1 | 14.9 | 13.9 | 12.9 | 12.0 | 11.2 | 10.4 | 9.7 | 9.0 | 8.4 | 7.8 | 7.2 | 6.7 | 6.3 | 5.8 |
| | | | | | | | | | | | | | | | |
| NPV benefits | 307.4 | | | | | | | | | | | | | | |
| npv costs | 152.9 | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Net benefit | 154.5 | | | | | | | | | | | | | | |

**Table A6: Worst Case Scenario Net Present Value Calculations $m**

| **Benefits** | Y1 | Y2 | Y3 | Y4 | Y5 | Y6 | Y7 | Y8 | Y9 | Y10 | Y11 | Y12 | Y13 | Y14 | Y15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Productivity benefit of providing better training | 0.0 | 0.0 | 0.0 | 0.0 | 1.7 | 3.4 | 5.1 | 6.8 | 8.5 | 10.2 | 11.9 | 13.6 | 15.3 | 17.0 | 18.7 |
| Efficiency benefit from licence category change | 0.0 | 0.0 | 0.0 | 0.0 | 7.8 | 7.8 | 7.8 | 7.8 | 7.8 | 7.8 | 7.8 | 7.8 | 7.8 | 7.8 | 7.8 |
| SMS safety improvement | 0.0 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| SMS efficiency improvement | 0.0 | 18.1 | 18.1 | 18.1 | 18.1 | 18.1 | 18.1 | 18.1 | 18.1 | 18.1 | 18.1 | 18.1 | 18.1 | 18.1 | 18.1 |
| Safety benefit from Part 42 | 0.0 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Total undiscounted benefits | 0.0 | 19.4 | 19.4 | 19.4 | 28.9 | 30.6 | 32.3 | 34.0 | 35.7 | 37.4 | 39.1 | 40.8 | 42.5 | 44.2 | 45.9 |
| Discount factor | 1.0 | 0.9 | 0.9 | 0.8 | 0.7 | 0.7 | 0.6 | 0.6 | 0.6 | 0.5 | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 |
| Total discount benefits | 0.0 | 18.0 | 16.8 | 15.6 | 21.6 | 21.3 | 20.9 | 20.5 | 20.0 | 19.5 | 18.9 | 18.4 | 17.8 | 17.2 | 16.6 |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| **Costs** | | | | | | | | | | | | | | | |
| Diploma training of engineers | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 |
| Maintenance exposition | 16.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| SMS costs | 6.1 | 16.4 | 16.4 | 16.4 | 16.4 | 16.4 | 16.4 | 16.4 | 16.4 | 16.4 | 16.4 | 16.4 | 16.4 | 16.4 | 16.4 |
| Set up CAMO | 5.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Prepare Exposition | 0.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Aircraft Reviews | 14.3 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Overseas maintenance | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | | | | | | | | | |
| Total undiscounted costs | 46.6 | 19.0 | 19.0 | 19.0 | 19.0 | 19.0 | 19.0 | 19.0 | 19.0 | 19.0 | 19.0 | 19.0 | 19.0 | 19.0 | 19.0 |
| Total discounted costs | 46.6 | 17.7 | 16.5 | 15.3 | 14.2 | 13.2 | 12.3 | 11.4 | 10.6 | 9.9 | 9.2 | 8.6 | 8.0 | 7.4 | 6.9 |
| | | | | | | | | | | | | | | | |
| NPV benefits | 254.9 | | | | | | | | | | | | | | |
| npv costs | 199.0 | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Net benefit | 55.9 | | | | | | | | | | | | | | |